

IBS studies in RHIC (2004-2005)

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Dedicated IBS measurements (for Gaussian beam; IBS for distributions under electron cooling is not covered in this talk)

Set-up:

- Long bunch, small dp/p (RF: $h=360$, 300 kV)
- no losses from the bucket
- no collisions
- clean growth of emittance and bunch length
- bunches with different intensity – to test dependence of growth rates on bunch intensity and emittance

Run-4: Au ions

- 6 bunches of different intensity

Data:

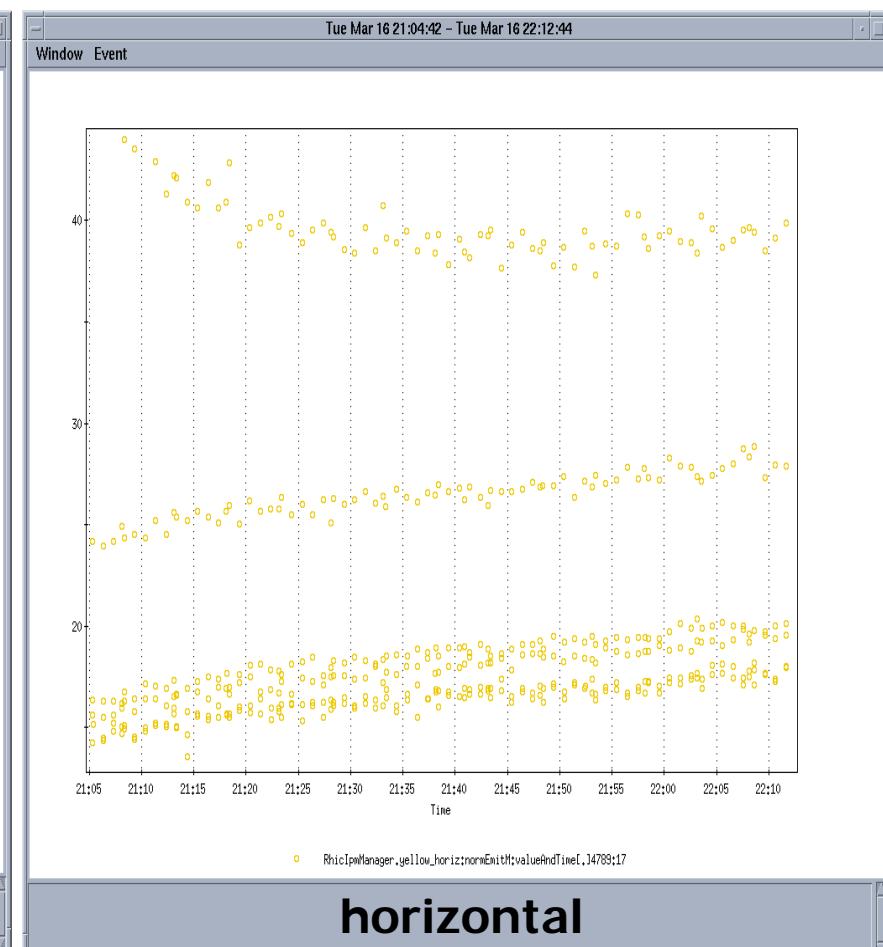
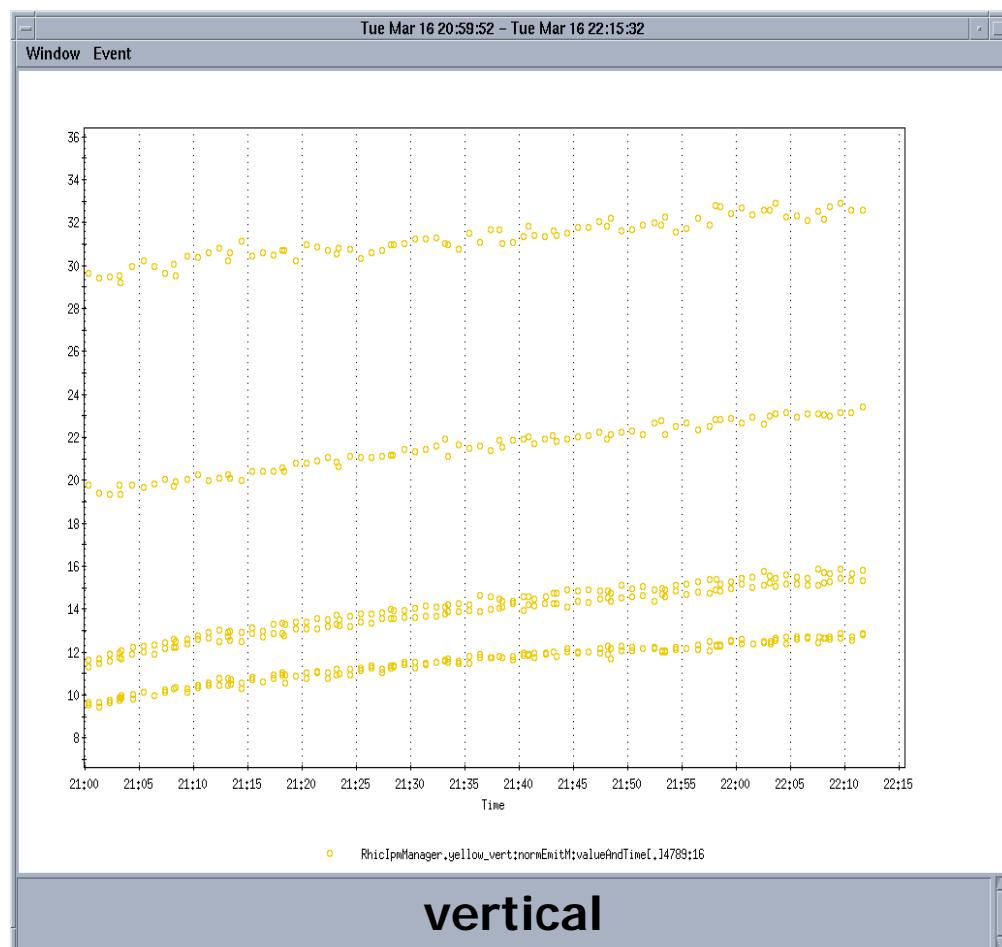
both in **BLUE & YELLOW** rings

Longitudinal: good data

Vertical: yellow - good, blue - ok

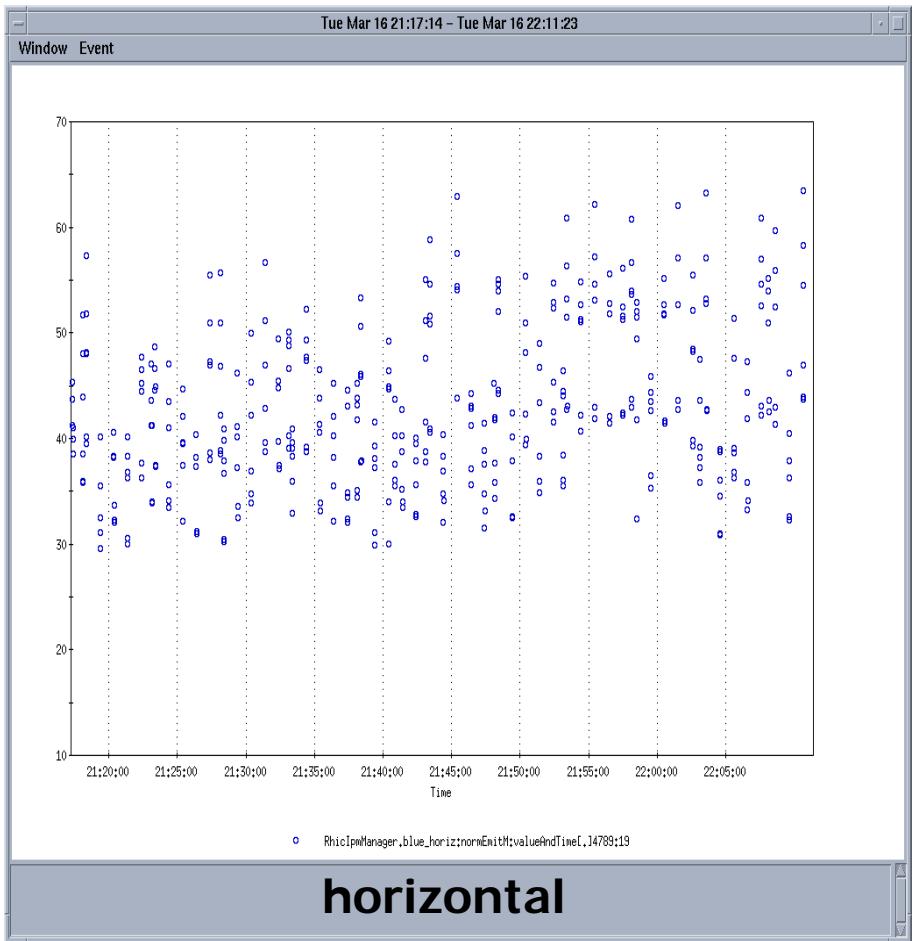
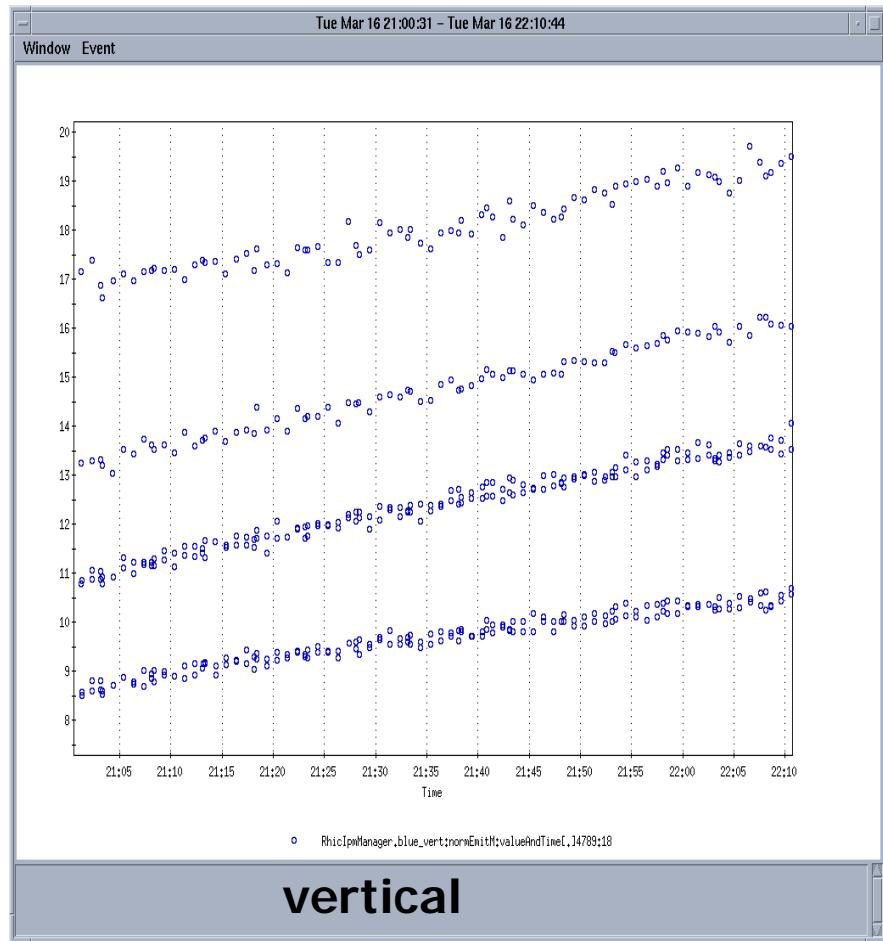
Horizontal: yellow - good, blue - bad

Yellow: Transverse emittance growth - IPM measurements



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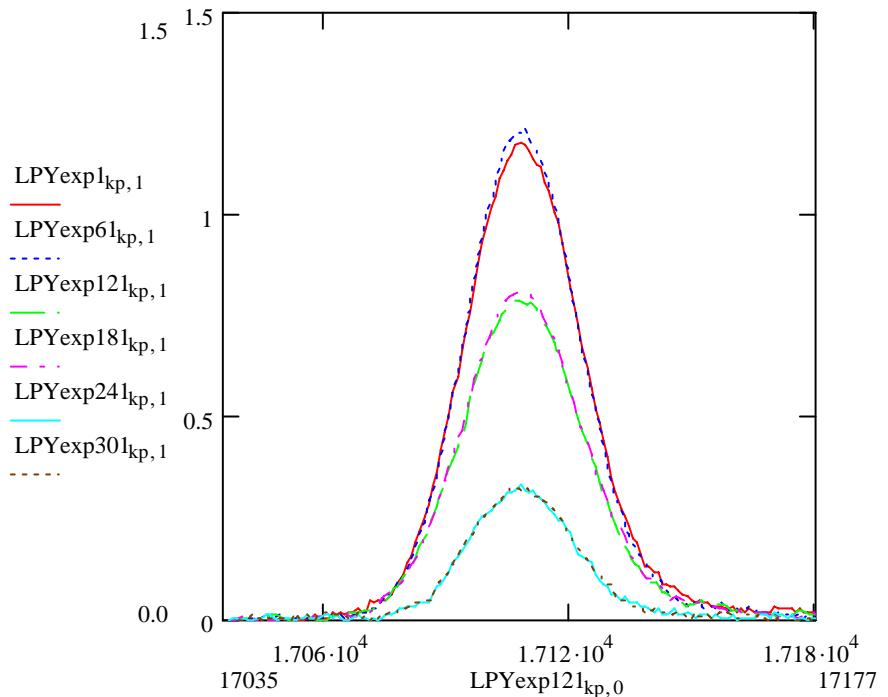
Blue: Transverse emittance growth - IPM measurements



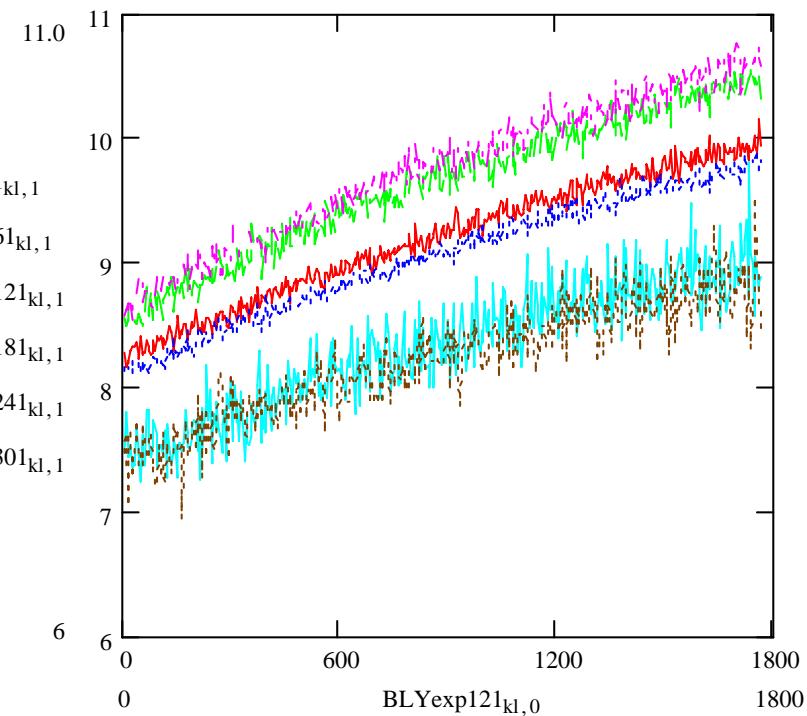
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Measured bunch length (Exp. #4790)



initial longitudinal profiles



FWHM vs time

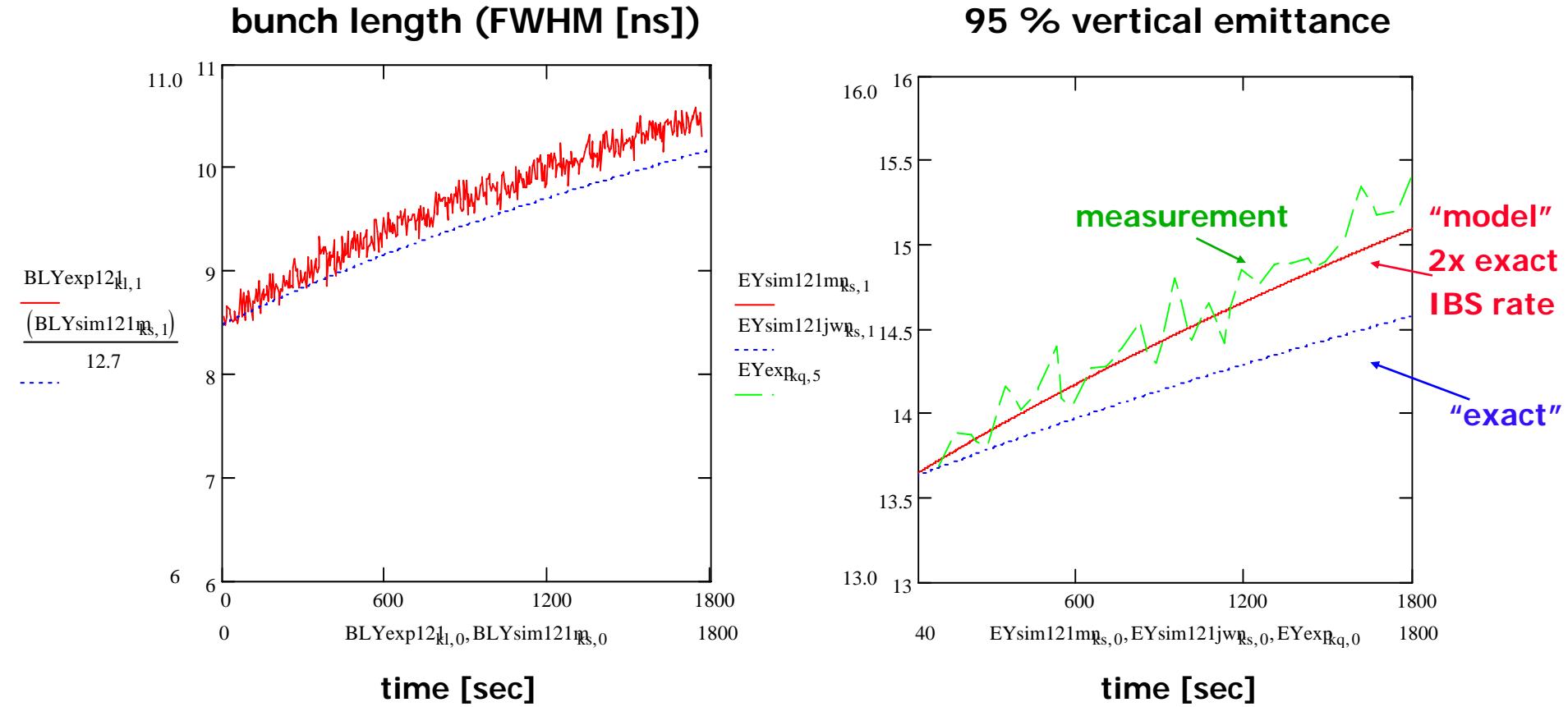
IBS for Run-4 – simulation models

IBS calculation using BETACOOL code based on:

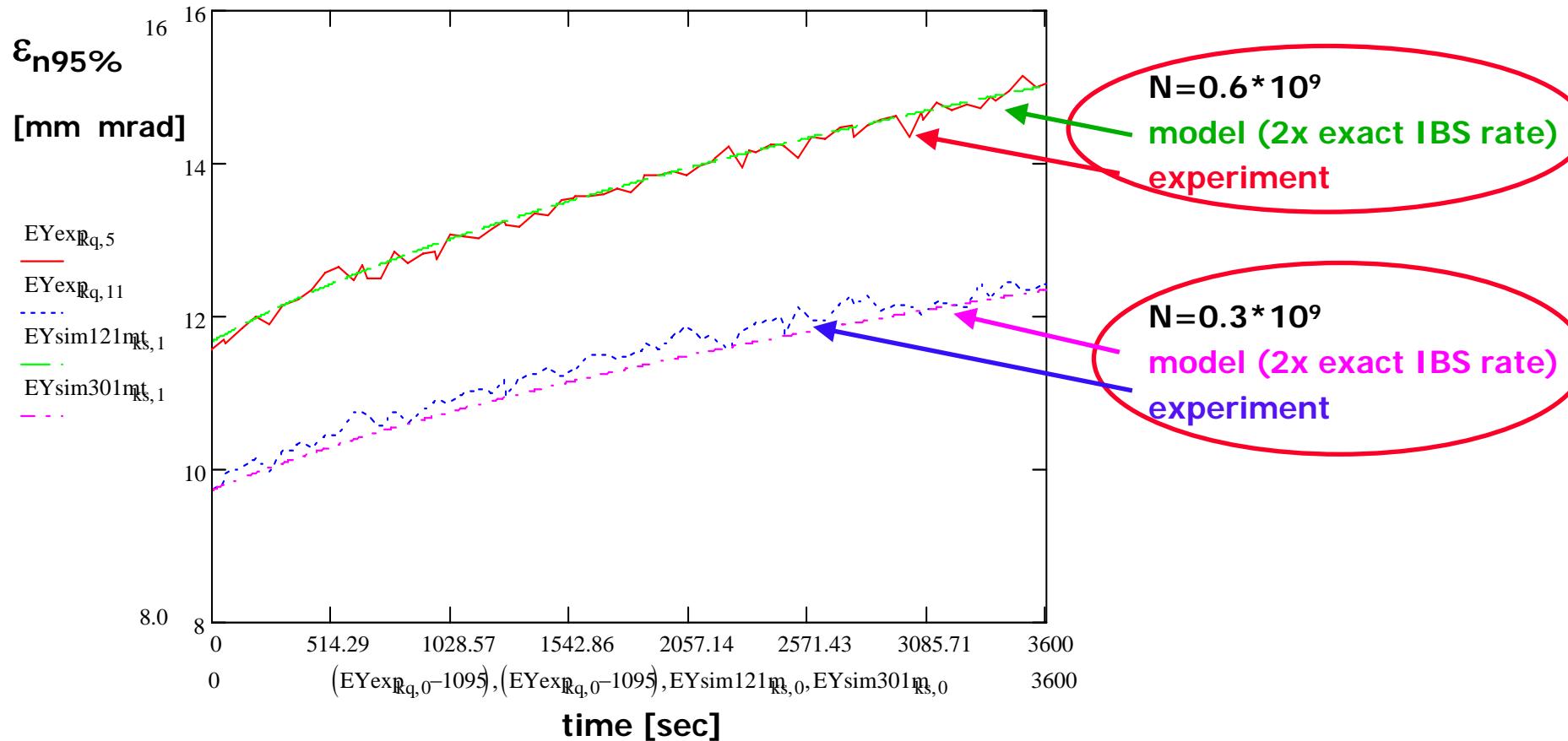
Martini's formalism of IBS:

- 1) RHIC-4 MAD lattice - "exact"
- 2) RHIC-4 lattice with higher dispersion
(or FODO for full length instead of real lattice) - "model" -
2x "exact"
IBS growth
rate

Bunch in the bucket # 121 - growth at store during the time of 1 hour



Experiment #4789, bunches 121 and 301 - measurement and simulations for two different intensities



Summary based on Au ions (Run-4)

Longitudinal growth:

- Measurements are in good agreement with simulations

Transverse emittance growth:

- “Exact” IBS based on the full RHIC lattice - underestimates transverse growth rates by a factor of 2.
- “Model” (2x “exact” expected IBS) - goes through the measurements:

Uncertainties and assumptions:

1. Coupling was not measured. Assumed full coupling which divides horizontal rate in half - attempt to address in Run-5
2. Uncertainty about dispersion in real lattice vs model – not fully resolved.
3. Uncertainty in vertical dispersion (we assume zero, measured dispersion is not zero) – not resolved.
4. Emittance values based on IPM-04 – disagreement with other technique
5. Calibration of emittance values based on IPM bunch by bunch –not resolved.

Run-5: Cu ions

Done measurements:

At injection:

yellow - coupled
blue - decoupled



below transition energy –
IBS has different behavior

At store:

- measured dQ_{min} : both rings coupled
- no measurements with decoupling

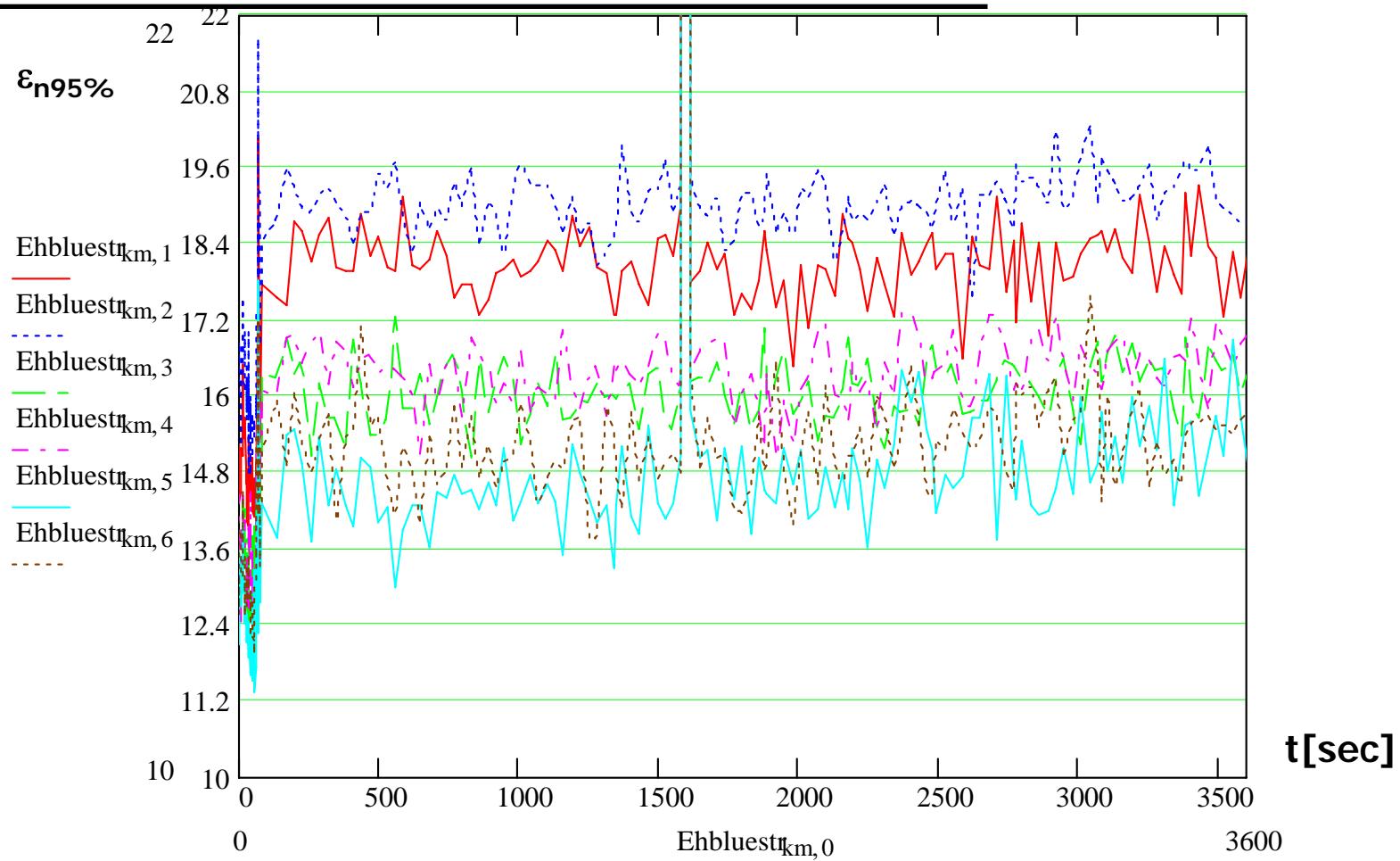
IBS for Run-5 (fill #6102 at store energy 100 GeV)

IBS calculation using BETACOOL code based on:

Martini's formalism of IBS:

- 1) RHIC-5 MAD lattice - "exact"
- 2) RHIC-5 lattice with higher dispersion - "model" (2x "exact" rate
as for Run-4).

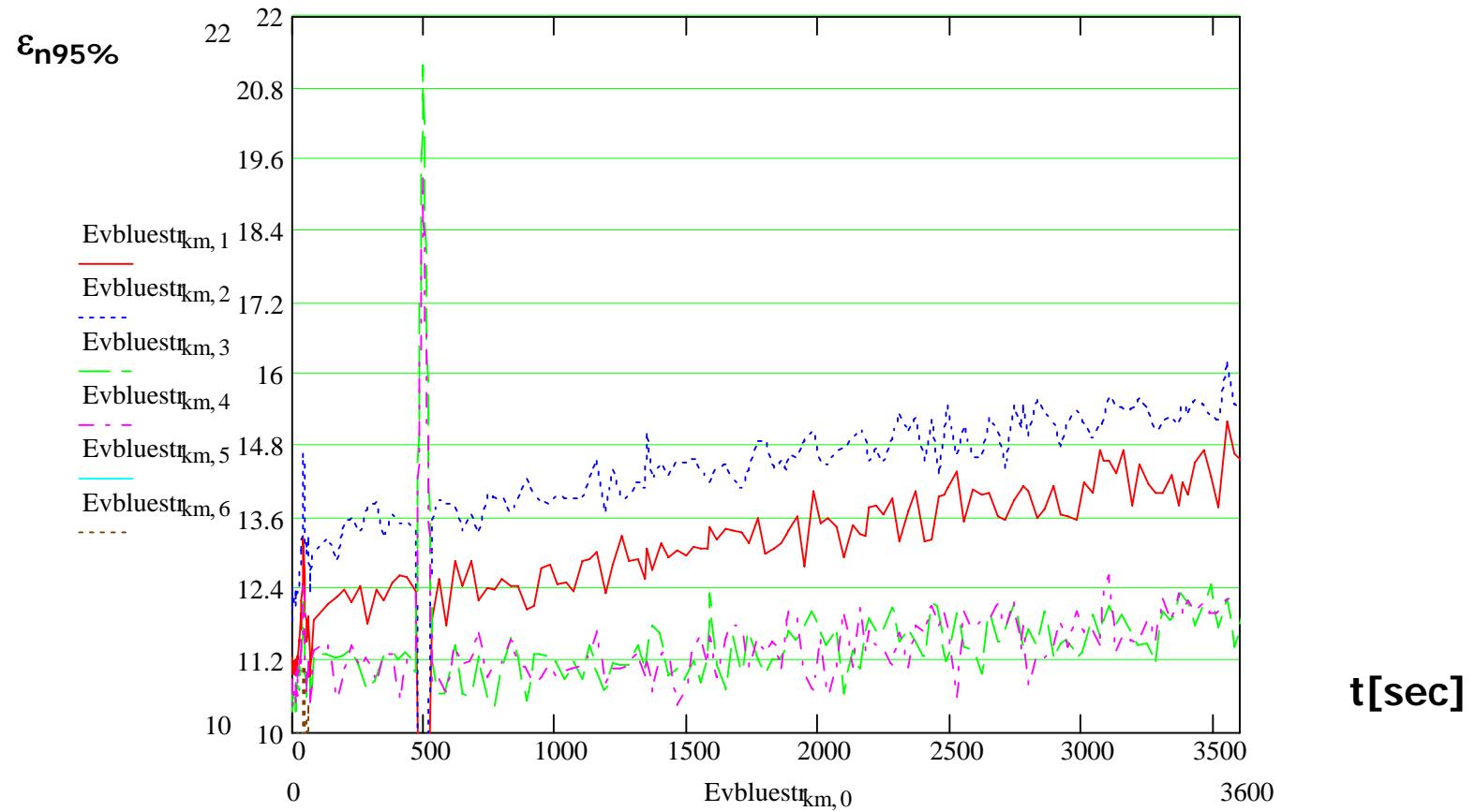
Horizontal emittance for six buckets in BLUE



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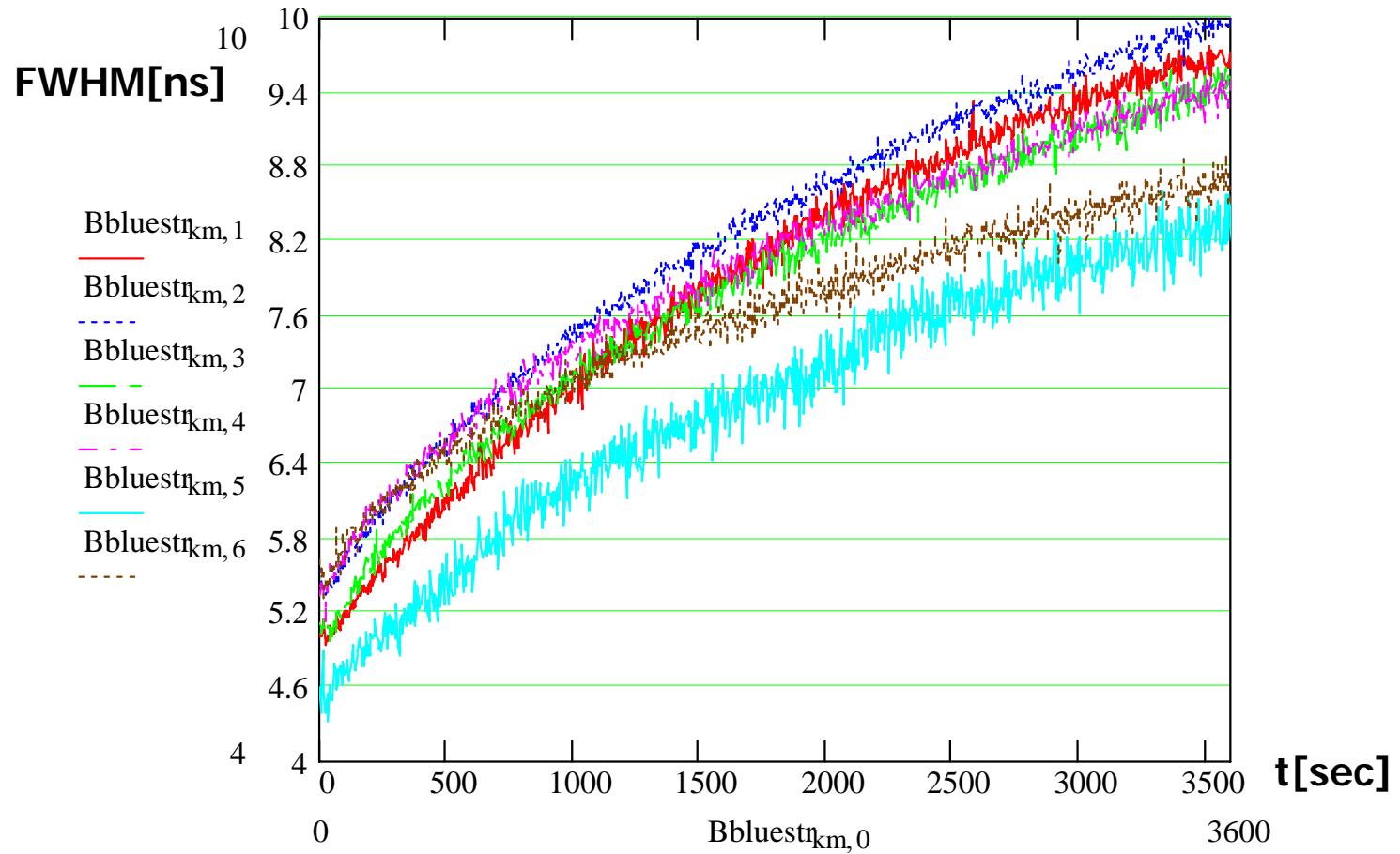
Vertical emittance for six buckets in BLUE



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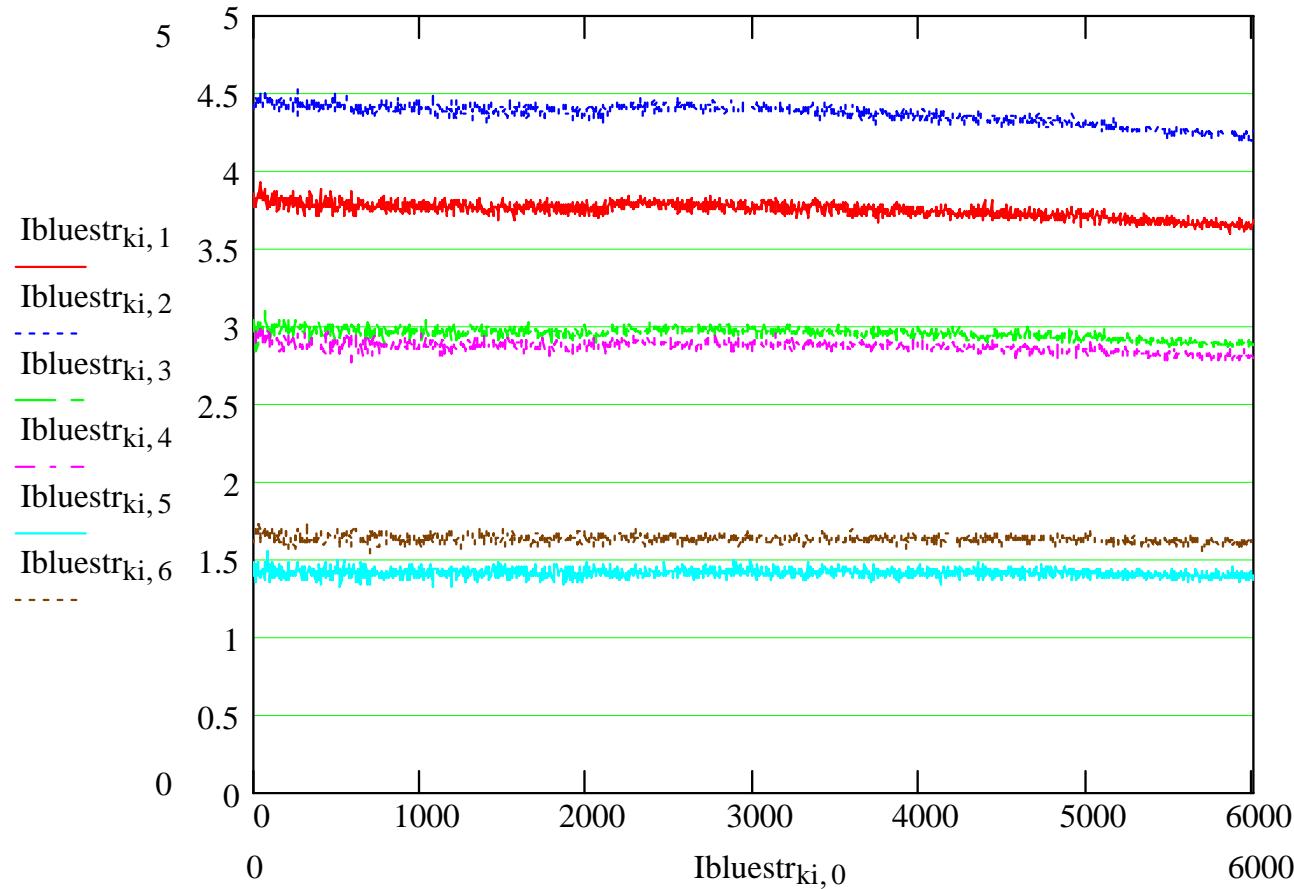
Bunch length for six buckets in BLUE



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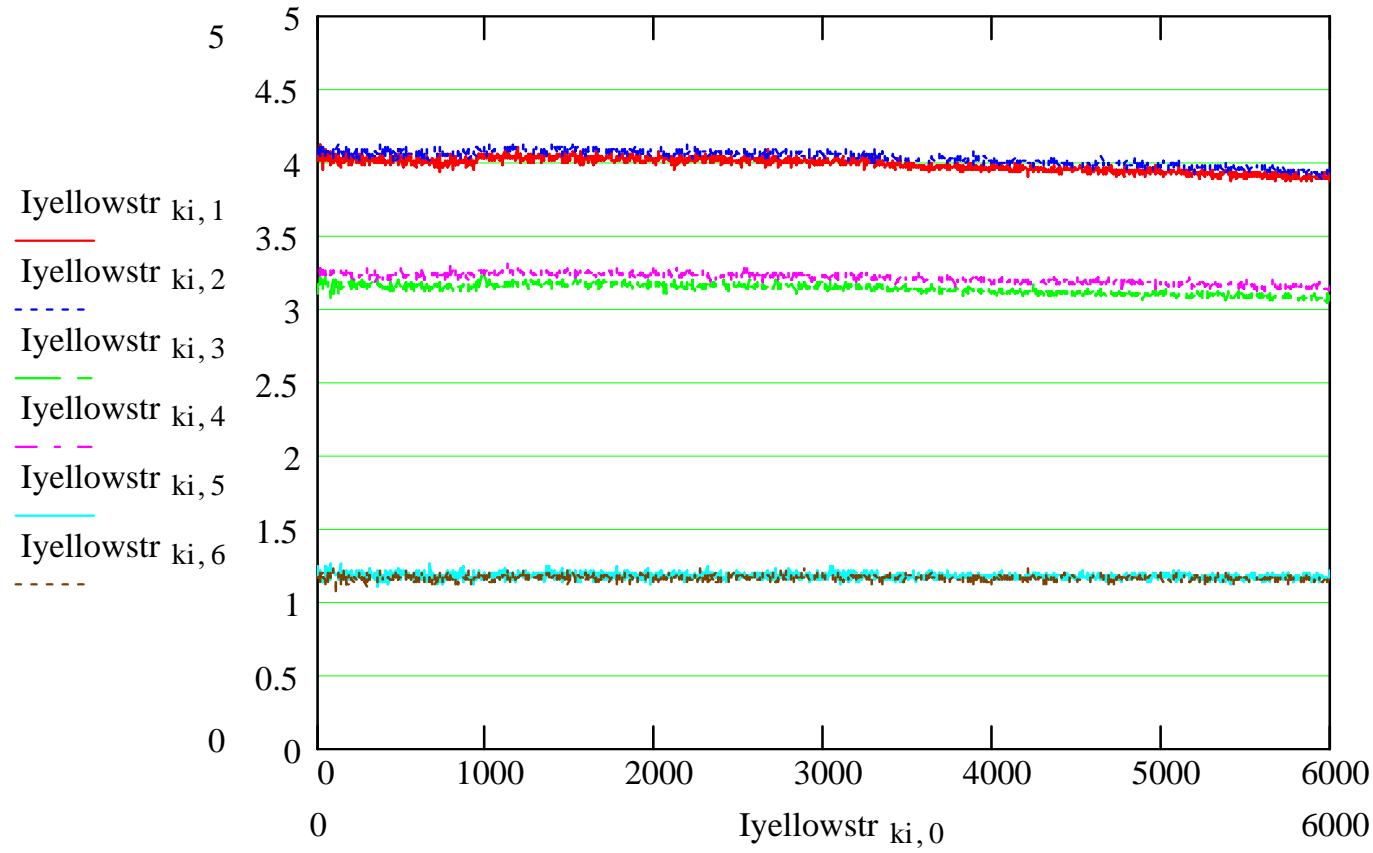
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Bunch intensities ($\times 10^9$) in BLUE

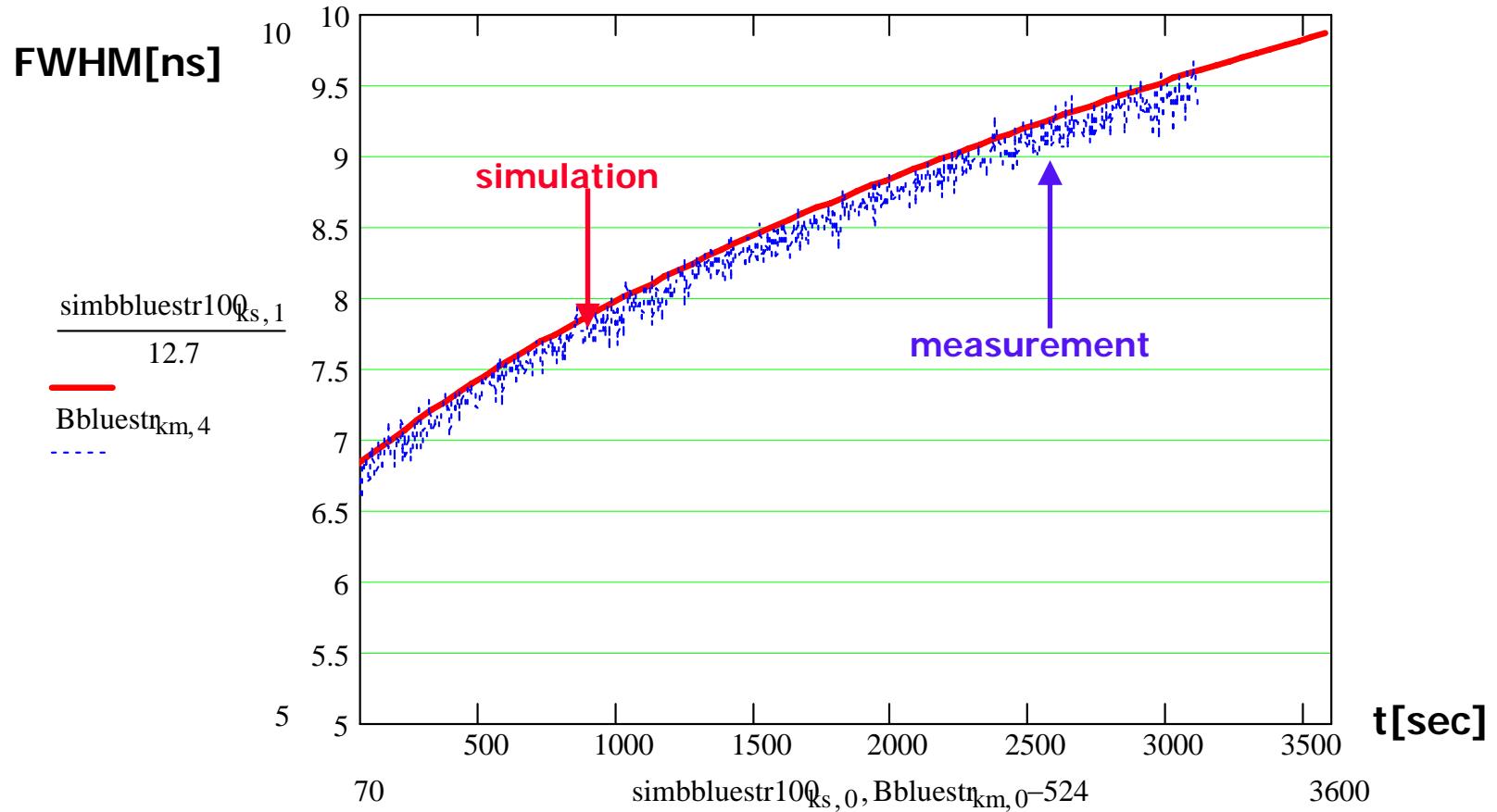


Similar measurements in **YELLOW**

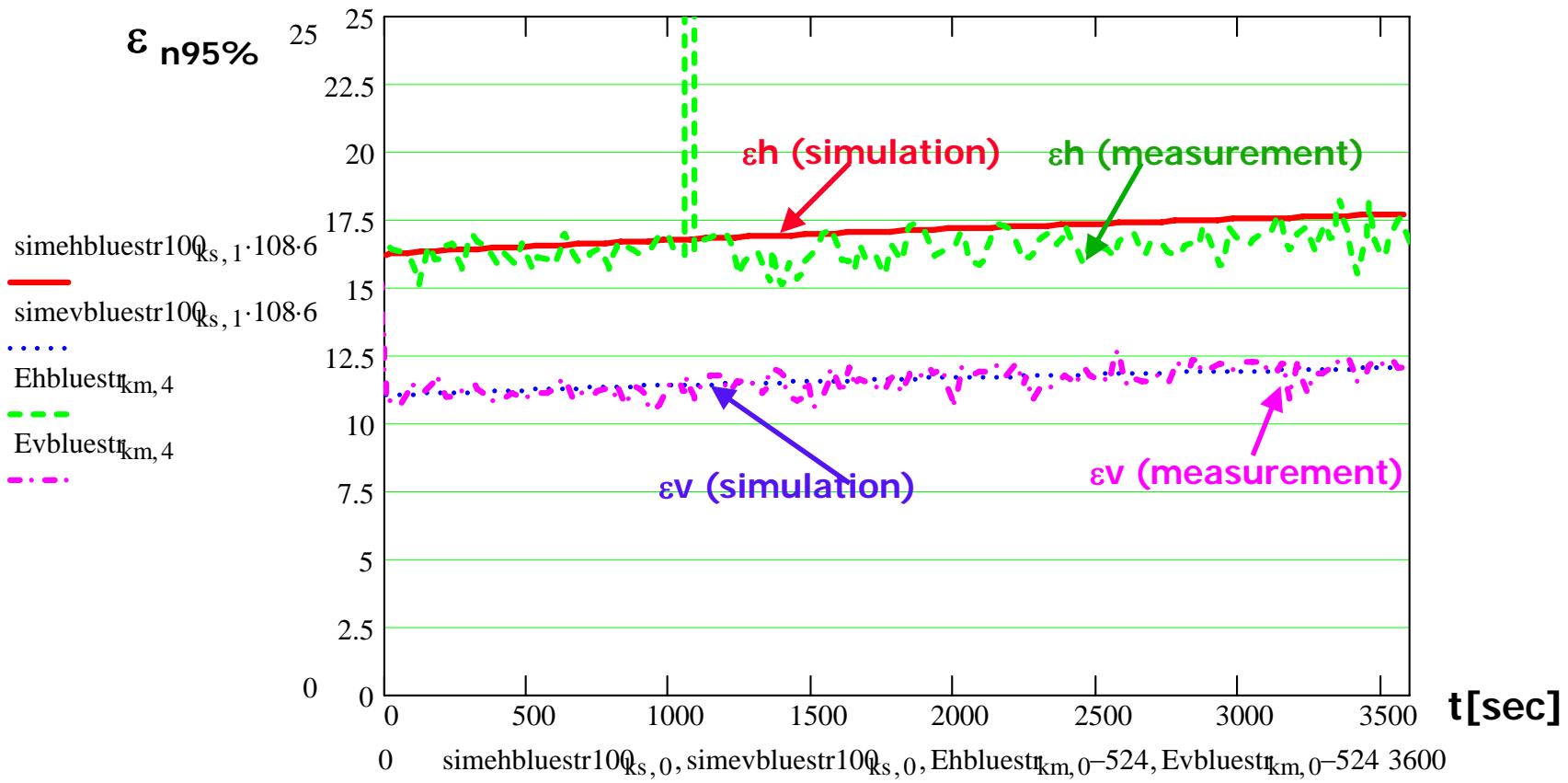
Example: bunch intensities ($\times 10^9$)



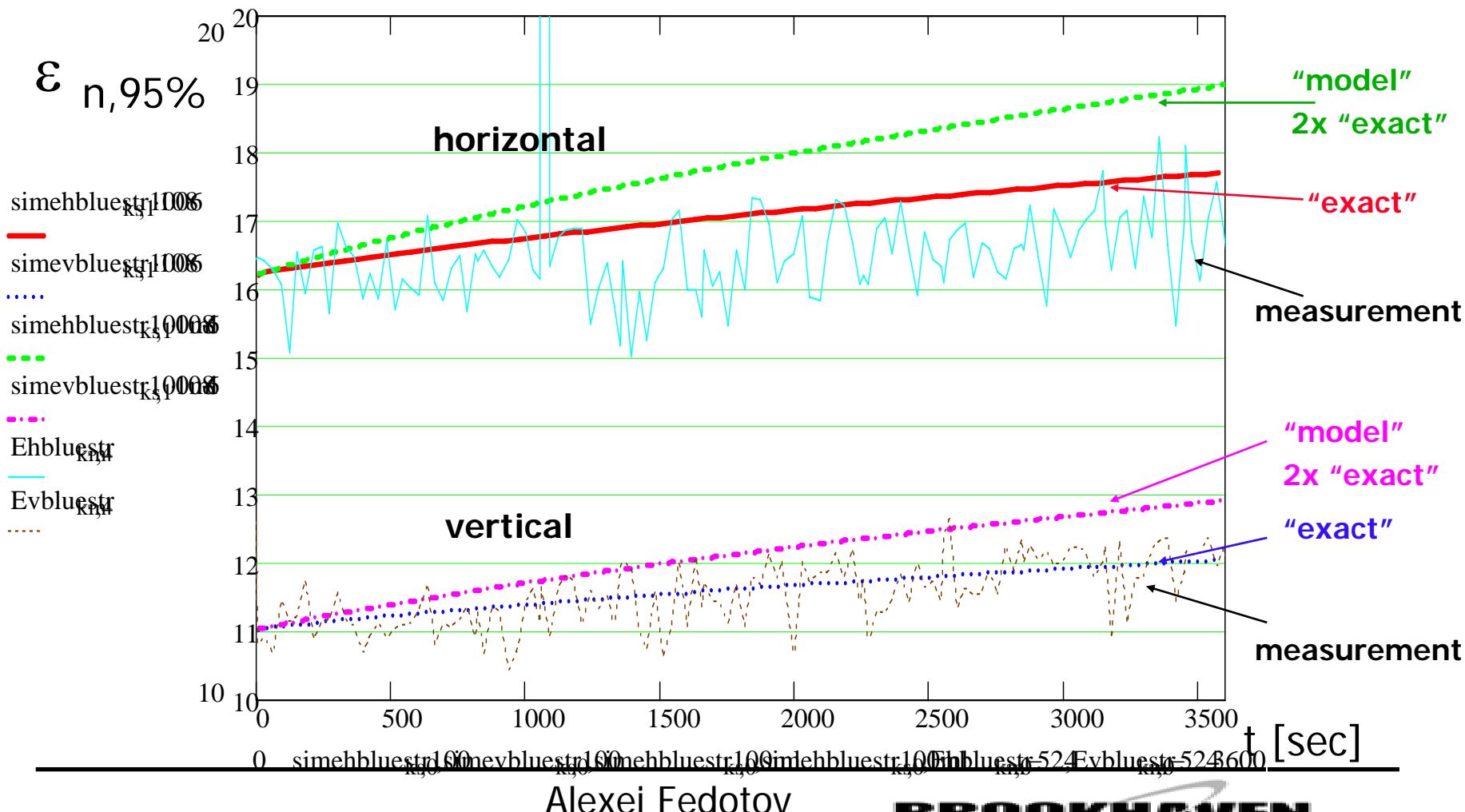
Bunch length - bucket #100 in **BLUE** ($N=2.9e9$) - measurement and “exact” simulations



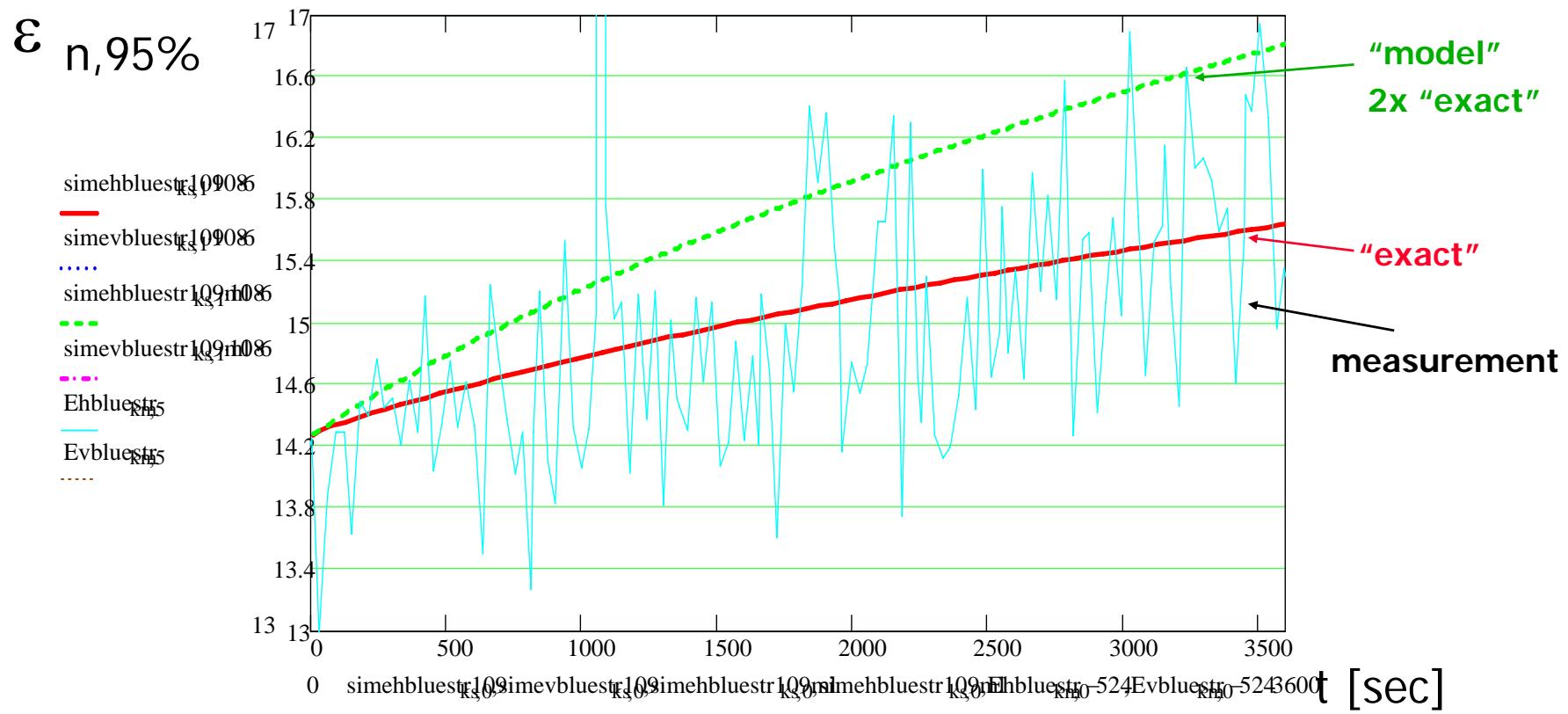
Horizontal and vertical emittance growth: bucket #100 in BLUE ($N=2.9e9$) – simulations (“exact”) vs. measurements



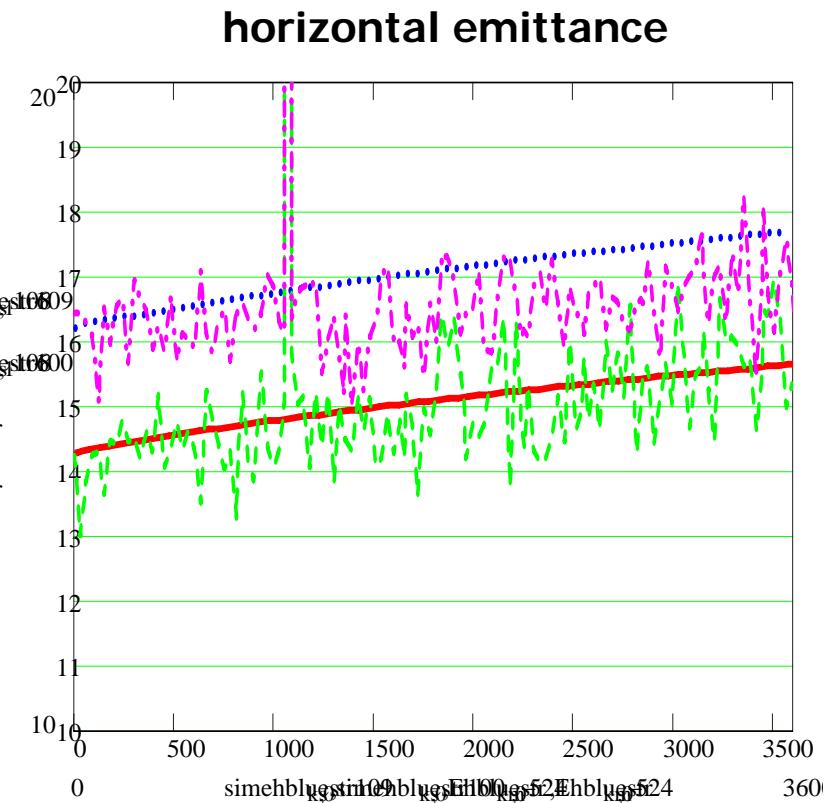
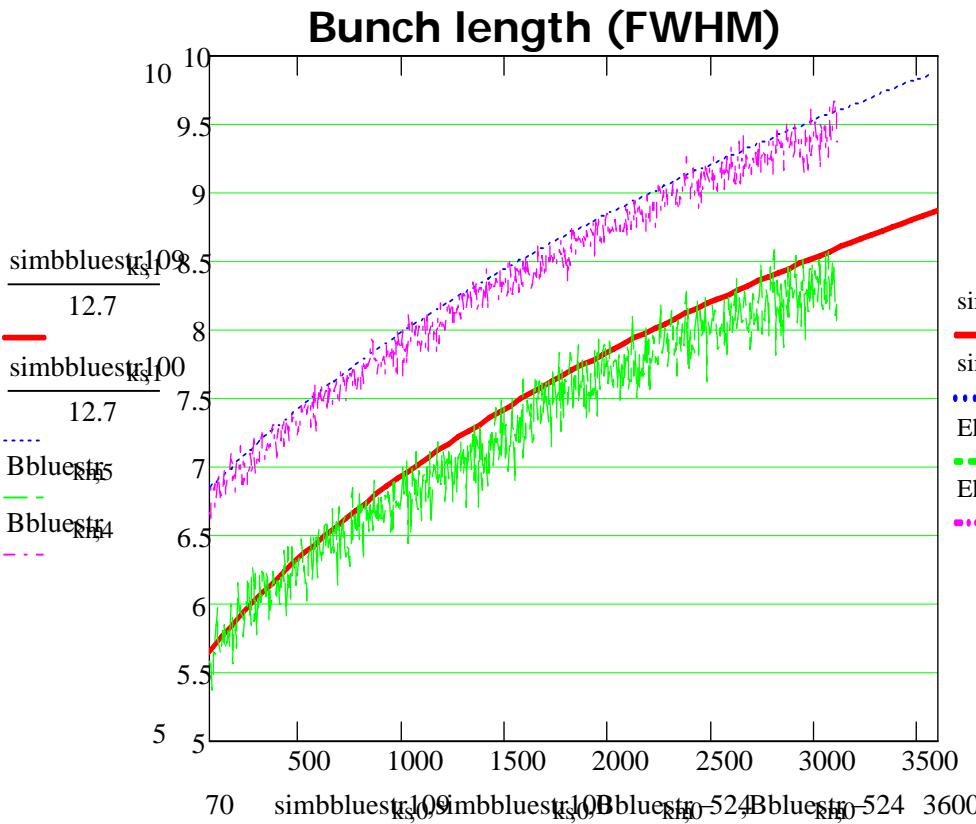
Bucket #100 in **BLUE** ($N=2.9e9$) - measurements and simulations with two IBS models



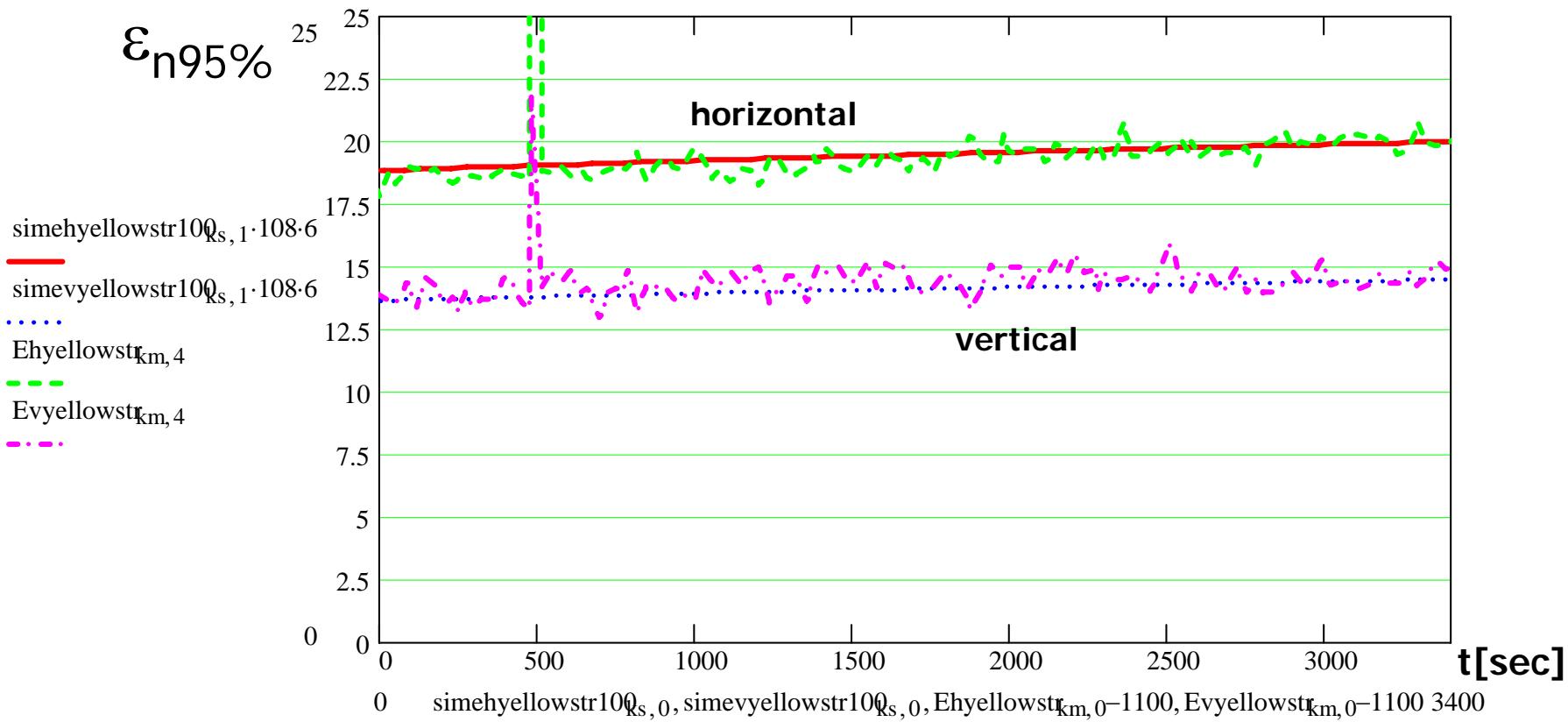
BLUE bucket 109 (low intensity, N=1.4e9) - measurement and comparison with simulations: “exact” and “model”



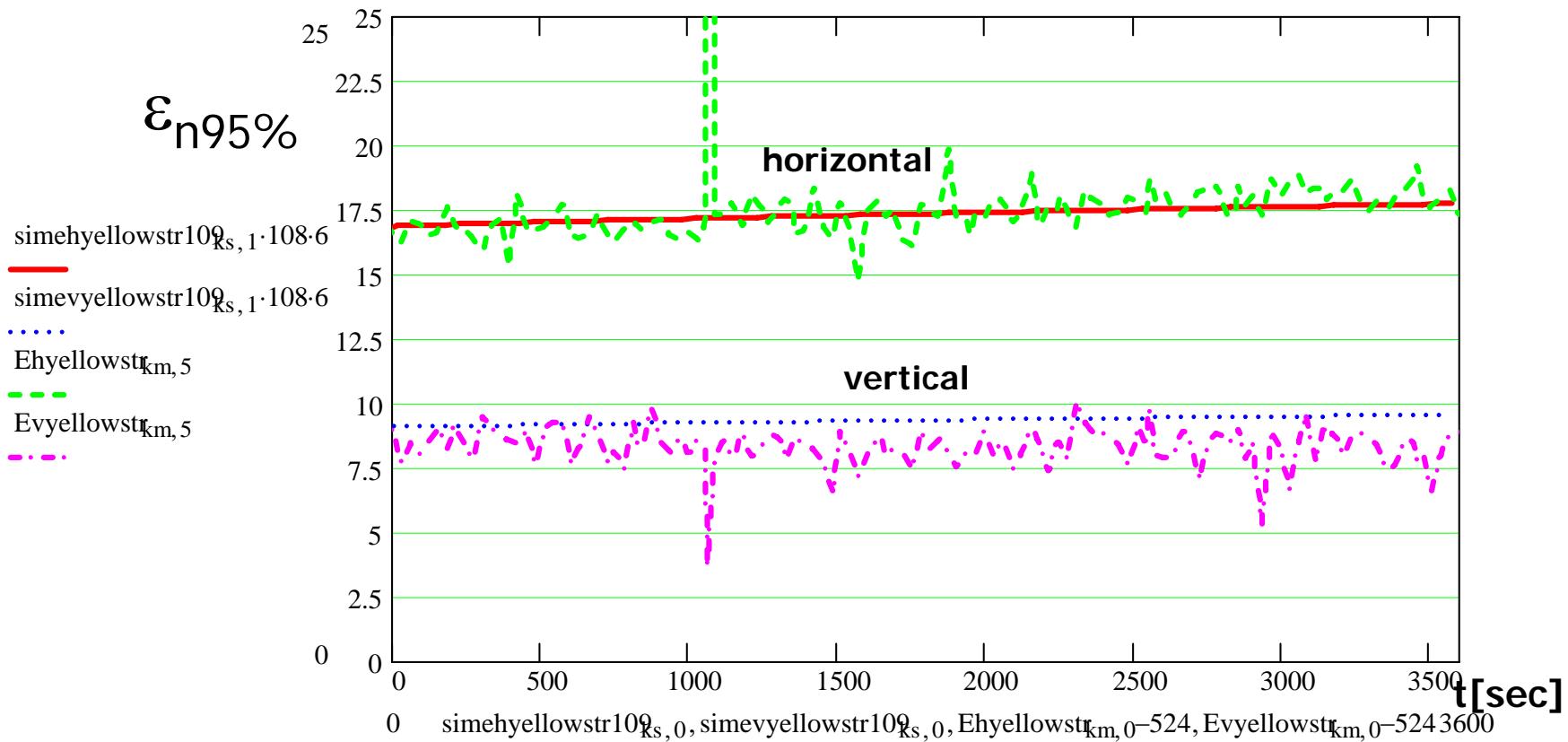
BLUE: two intensities ($N=2.9\text{e}9$ and $N=1.4\text{e}9$) - measurements and simulations (“exact”)



YELLOW: bucket #100 (high intensity N=3.3e9) - measurement and simulations (“exact”)



YELLOW bucket 109 (low intensity N=1.2e9) - measurement and simulation



Summary based on Run-5 (Cu ions)

- We have good agreement between “exact” IBS description and measurement.

Why it did not work for Au ions? :

- 1) we had too many assumption
- 2) measurements were not good enough
- 3) there was/is other possible source of diffusion for Au ions

What we need in the future:

For Au-Au run:

At store: Repeat similar measurement with and without coupling at store
– with IPM working in both planes.